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THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION.

W. A. WITHERS, A. M., ACTING DIRECTOR.

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DRINKING WATER.

CITY, TOWN AND RURAL SUPPLIES.

A. W. BLAIR.

RALEIGH, N. C.

Publications will be sent to any address in North Carolina upon application

NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS,

RALEIGH, N. C.

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DRINKING WATER.

City, Town and Rural Supplies.

A. W. BLAIR, A. M., State Chemist.

Introduction.

As this Station is often called upon to analyze samples of drinking water for the public, the publication of a bulletin of a general or popular nature giving some facts concerning the purity of water, the proper construction and care of wells, methods of collecting and sending samples, interpretation of results, and the effect of impure water on health, does not seem out of place.

The importance of having a pure wholesome drinking water, cannot well be over-estimated, and yet gross carelessness in this matter exists almost everywhere.

There may be a difference of opinion as to the construction to be put upon the terms pure and wholesome, but we are certainly not requiring too much when we ask that the water be almost entirely free from organic matter, both vegetable and animal; that it contain only a small amount of mineral matter in solution; be free from any odor (unless indeed it is a sulphur water) and free from any unnatural color. These requirements may indeed be met and still the water be impure, as when water, which to the unaided eye has every appearance of being pure, is fouled by typhoid fever germs. These germs, however, do not thrive so rapidly when there is little or no organic matter present and on this account much reliance may be placed in the test for organic matter. Dr. Frankland defines the essential qualities of a good drinking water to be "first, coolness and æration; secondly, freedom from organic matter of all kinds; thirdly, that it should never have been contaminated with sewage or manure in any form, and finally, that it should be soft water, not over 5° of hardness."

Purity of Water.

Water, when judged by the chemical standard, does not occur pure in nature; even rain water caught in mountainous districts, far from the smoke of cities and the abodes of men, contains traces of impurities taken up from the air. When, however, the foreign substances are present in such small quantities as not appreciably to affect the physical properties and render it unfit for drinking purposes, it is popularly spoken of as pure.

Solvent Properties of Water.

Water has remarkable solvent properties and it is on this account that it becomes so readily contaminated. The number and variety of substances which it can take into solution greatly exceed that of any other fluid. Some substances as sugar and common salt dissolve with ease and considerable rapidity, while others, such as rocks of a granitic or sandstone nature, are almost entirely insoluble in water. Limestone, however, dissolves slowly in water which contains carbon dioxide in solution, and in this way certain waters become charged with limestone and other salts (sulphates and chlorides) to some extent, and are spoken of as "hard waters." The carbon dioxide is gathered by rain water, in small quantities from the atmosphere, but is obtained in much larger quantities from the soil, as it percolates through it where there is decomposing vegetable matter.

Waters which contain very small quantities of lime and magnesia salts are called "soft" since they lather freely with soap. Where these salts are present in considerable quantities a certain amount of soap is required to decompose them before a lather can be formed. If the hardness is caused by limestone it is called temporary, and can be remedied, to a great extent, by boiling the water. The boiling causes the carbon dioxide to be driven off and then the greater part of the calcium carbonate (limestone) settles to the bottom of the vessel. If the hardness is due to sulphates it is called permanent and the water is not rendered "soft" by boiling. Many gases are also readily dissolved or absorbed by water. Among these may be mentioned hydrochloric acid and ammonia, which are readily absorbed, and oxygen and nitrogen which are dissolved in much smaller quantities. This property of dissolving or absorbing gases is a very important one. It explains how waters may become contaminated by mere exposure to impure atmosphere, as when an uncovered cistern is so placed that impure gases may come in contact with the water.

The materials which are commonly found in natural waters may be classified as follows: Gasesous and Solids.

The gasesous materials are carbon dioxide, oxygen and nitrogen. The solids may again be classified as mineral and organic. The mineral matter consists chiefly of carbonate of lime and magnesia; sulphate of lime, magnesia and soda; chloride of sodium (common salt), and often a salt of iron. The organic material is the product of decomposed animal and vegetable matter. In addition to these many waters contain matter in suspension and this may be divided into organic, such as finely divided particles of dead vegetable matter and minute forms of vegetable and animal life, either living or dead; and inorganic substances such as fine soil, sand and clay.

Many mineral waters contain other chemical compounds not mentioned here, and some contain hydrogen sulphide in addition to the gases mentioned.

Sources of Drinking Water.

By far the greater portion of water which is used for drinking purposes, may be divided into the following classes according to the sources from which it is directly obtained:

Rain water.
Well Water { Driven. / Dug. / Artesian.
Spring water.
River water.

The impurities which are found in rain water are such as it has gathered from the air, in its passage to the earth, or from the roof upon which it fell. These impurities are: from the air, ammonia, carbon dioxide, and dust (ammonia and carbon dioxide are always present in the air in small quantities but do not in any way hurt the water for drinking purposes), and organic matter from the roof. If care be taken to keep the roof well cleaned off and the portions which are first caught after the rain begins, are thrown away, that which falls afterwards is very pure and makes excellent drinking water. Well water may be divided into two classes, that which comes from deep wells and that which comes from shallow wells. Of the two kinds the shallow well water is much more liable to be contaminated than that which comes from deep wells. Several reasons may be assigned for this. As a rule, shallow wells are not so thoroughly constructed as deep wells and consequently impurities enter more easily from the top, and in addition the surface water which makes its way into the well is apt to be charged with impurities gathered up from the surface near dwellings, barns and other buildings, and owing to the small amount of earth through which it has to filter these impurities are not oxidized and thus destroyed before they reach the water in the well.

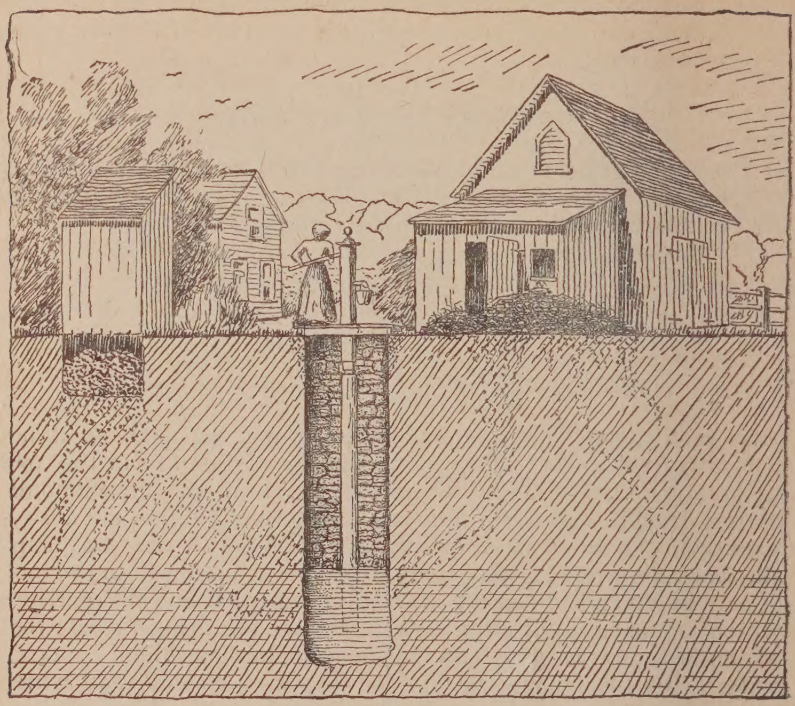

Fig. 1.—The shallow barnyard well, with privy vault and manure heaps near by. The water is likely to receive fluid from these at any time. (From Smith's Sewage Disposal on the Farm, Farmers' Bulletin No 43, U. S. Department of Agriculture.)

The water of deep wells on the other hand has to pass through thick layers of earth, sand and gravel and before it reaches the bottom of the well, the organic matter which it carried in suspension and solution has become oxidized and converted into harmless nitrates.

While in many instances the earth thus acts as an excellent filterer and purifier of water charged with filth, still it cannot always be depended upon to perform this office, since it is possible for it to become overcharged with filth, in which case it would cease to purify the water which percolated through it. As it is beyond the power of any one (at least without a chemical or biological examination) to tell just when the earth is acting as a filter, and when it ceases to do this work on account of over-saturation with filth, the only safe way is to see that no surface water is allowed to enter the well and also not to allow anything which may prove to be a source of contamination to the water, to accumulate on the surface within a radius of 75 to 100 feet of the well.

Organic matter of any kind is objectionable in potable waters,

while that derived from sewage or material of like character is highly dangerous, since it is in such waters that disease germs are most likely to exist, and multiply most rapidly. Hence it is that every possible precaution should be taken to prevent such material from entering the well The mineral matter which is held in solution may also prove to be a source of impurity in well water, though unless it is present in excessive amounts, this is, as a rule, harmless. The best waters rarely ever contain more than 15 to 20 grains per gallon of mineral matter, though this limit may be doubled and still the water be wholesome. Even perfect filtration by the earth would not always insure a pure water supply, for disease germs are sometimes carried by the water for a long distance under ground. Spring water, when the springs are properly cared for is usually of a high degree of purity, there being but little organic matter present in them, while the mineral matter when present in any considerable quantity, is often beneficial rather than injurious in character. Springs should be frequently cleaned out, and so constructed that surface water cannot run directly into them.

River water is used but little for drinking purposes except as it is used as the supply for large cities, and to treat this subject properly would require a special paper. It may be said in passing however, that as cities increase in population and as rural districts become more thickly inhabited, this question becomes more serious and the responsibilities of those in charge much greater. The excreta of one typhoid fever patient is sufficient, and has been known, to contaminate the water supply of a city.

The Construction and Care of Wells.

Although the shallow well is an institution of very early times, yet but few have been the improvements that have been made in its construction. In almost every other department of engineering, improvements have advanced with rapid strides but the shallow well, with (too often) the "moss covered bucket" seems to remain a heritage of the oldest civilizations. In some parts of this State wells can even now be found without anywall or lining, and many that are walled are scarcely better than those that are not, for they are so constructed that the surface drainage, which always contains more or less filth, (often more), can flow directly into them and thus contaminate any pure water which may have entered from the bottom. Others are left open at the top all the time, so that filth in the form of sticks, leaves, insects and even mice, rats and toads are not infrequently found, when the condition becomes so bad as to compel an examination. An instance has recently been brought to notice where a dead squirrel remained in a public well,

which was used by a great many people, about two weeks. Fortunately for those using the water, decomposition and putrefaction had not gone on to any great extent when the nuisance was detected. All such materials act as a source of contamination for the water; the leaves and the sticks being the least and the animal life, most harmful. Often parts of decayed curbing and covering are allowed to fall into the well, and these yield putrid organic matter to the water. Draw wells and dipping wells are also liable to be contaminated by the dirty vessels let down into them and especially is this true, where two buckets on one rope or chain are used, an arrangement which is often found at public wells, where the rope and bucket are handled by all classes.

In wells otherwise carefully constructed, filthy water is often allowed to run back into them through cracks in the pump platform, or along the track of the pipe leading from the pump to the well.

In a well properly constructed no water should be allowed to enter except that which comes from near the bottom, so that before reaching the well it must have passed through a considerable thickness of soil and thus have all the impurities which it may have originally contained, filtered out. This perfect filtration is not, however, always possible, as is instanced by the recent report made on the supply of potable waters of Camp Thomas at Chickamauga. From the report "it appears that nearly the whole camp is located above a magnesian limestone. The surface water passes directly through sink-holes and fissures into the small water pockets struck by the so-called artesian wells. Hence it has no chance of filtering and purifying itself, and after a freshet the wells give turbid water. There is obvious danger in drinking this water from a bacterian point of view and the report dwells upon the fact that this water, like that of most springs in limestone formation, being very "hard," not only fails to cook the food properly, but has an injurious effect upon nutrition." In the report, fault is found with the spring water, which after the other supply was abandoned, was hauled in barrels from different sources of supply. It appears that it was the custom to place an old canvas sack over the top of the barrel below the lid to prevent the spilling of the water. These sacks were often on the ground or on the floor of the wagon, and the impurities they picked up were washed out into the barrel by the splashing of the water against them. The report concludes by saying "that the terrible increase of sickness which has caused the camp to be abandoned has had the water supply for the main if not the exclusive cause. The July rains washed the microbe-laden atmosphere and the polluted soil, and carried the morbid material into the pockets of water struck by the pumps.

The spring water was polluted by the canvas bags and the muddy

bottoms of the pails. These causes account for the malarial and typhoid cases, while the loss of vitality, the lumbago, rheumatism, and stomach disorders are due, for the most part, to the hard water of the pumps and springs." This report only goes to confirm the fact which has already been well established, viz: that impure water is decidedly injurious to health, and that soldiers are no less likely to become victims of its use, than are ordinary men and women.

Several methods of preventing surface water from getting into wells have been suggested, but only brief reference can be made to the subject in this bulletin. Where the excavation is through solid rock, the walling with a cylinder of brick work or other material, will only be necessary to keep out the water from the more pervious surface soil. If it is desired, this wall may rest upon the top of the rock, but should be well lined inside with hydraulic cement and a joint should be made which is well nigh impervious to water. Where the excavation is all the way through clay or sand the work of lining is not quite so simple. For this work, however, terra cotta tubing has proved to be an excellent substitute for brick and rock. This tubing can be had in diameters from ten to twenty four inches and when properly put in with cemented joints forms a lining which is almost water proof and has proved entirely satisfactory in many cases. In no case should the cement be used below the water line. Whatever may be used for the lining, whether it be stone, brick, or terra cotta it should extend from one to three feet above the ground, according to the requirements, and be securely covered so that no foreign matter can enter the well.

Another method which has been suggested for overcoming the objection to shallow wells (since they must be looked upon as a sort of necessary evil) is to fill them up to the highest water level with gravel, and then over the gravel with sand to the top. Of course an iron pipe would have to traverse the sand and gravel and be connected with a pump at the surface. In this way any water which entered the pipe at the bottom if it came from the surface, must first have filtered through a thick bed of sand and gravel, and this would greatly improve the water by oxidizing and destroying the organic impurities. It is important, however, that the superficial layer of sand should be at least six feet in thickness, and if the subsoil water is reached at a depth less than ten feet it is probable that this method will not afford complete protection.

While much attention is now being given to the perfecting of systems of water works for large cities, it is still important that the supplies for small towns and rural districts be not neglected, and it is along this line that much can yet be done. By improving wells along some of the lines suggested above, the spread of typhoid

fever, in so far as it is due to water, may be restricted to a great extent. Wherever it is possible artesian wells are especially desirable since the water which comes from great depths in the earth is in most cases of high organic purity, and is not subject to contamination by impure surface water.

The Chemical Analysis.

The chemist is not able by purely chemical methods to detect disease germs as such in drinking water, but he is able to detect the presence of organic matter, and in an approximate way determine the amount of it, and as has already been stated, it is only when the organic matter is present that these disease germs can develop and multiply. If, therefore, any given water is very free from organic matter it is reasonable to suppose that there is little danger from specific disease germs.

Ammonia: By determining the amount of free and albuminoid ammonia, in a drinking water, the chemist can say whether there is much or little organic matter present and is also able in some instances to say whether it is of animal or vegetable origin, and this alone is an important step and furnishes valuable information when it comes to interpreting results. A water may contain a large amount of free ammonia and still be a good drinking water if there is little or no albuminoid ammonia present, but if there is a large quantity of albuminoid ammonia present the water must at least be considered suspicious, even if there is but little free ammonia. Chemists do not all agree as to the amount of ammonia which would be sufficient cause for condemning a water, but if free ammonia is almost entirely absent, it should not be condemned if the albuminoid ammonia does not exceed about .10 part per million. Albuminoid ammonia above .10 part per million is an indication that the water is of a suspicious nature and if it exceeds .15 part per million the water should be condemned, or at least immediate steps taken to correct the trouble.

Total Solids: The total solids are determined by evaporating a measured volume to dryness and weighing the residue. This gives the amount of matter that is held in solution and suspension by the water. The substances in solution may be of mineral or organic origin; the former derived from the rocks and soil with which the water has come in contact, and the latter from decomposing animals and plants, from manured soils, sewage, etc. No hard and fast line can be drawn indicating the amount of solids permissible in a drinking water, for that depends upon the character of the substances present. The purest drinking waters usually contain less than twenty (20) grains per gallon, but many excellent drinking waters contain double this amount.

Hardness: When, however, the total solids exceed about ten grains per gallon the usefulness of the water for domestic purposes may be greatly impaired on account of hardness. It is also claimed that vegetables cook more rapidly in soft than in hard water, and that for cooking meat and making soup, hard water is not so good as soft, as the former tends to compress the pores, while the latter tends to open them; also that soft water extracts the flavor of both vegetables and meat and the juice and gravy of the latter, much better than hard water. It is well understood that hard water is not suitable for boiler purposes. Waters under 5° or 6° of hardness may be considered "soft"; those exceeding 10° or 12° "hard."

Chlorine: The chlorine which is present in drinking water is usually due to the presence of sodium chloride (common salt) or other chlorides, which are in no way injurious; though it may be due to the presence of sewage, in which case it would be cause for condemning the water. The great danger in sewage polluted water is the possible presence of typhoid fever germs. Except where the total solids are high, a water which contains more than five (5) grains of chlorine per gallon should be regarded as suspicious. Recently a sample of water was analyzed in this laboratory which contained 56 42 grains of chlorine per gallon, and this amount under many circumstances, would have been sufficient cause for immediate condemnation, but when it was found that the total solid residue was 137.7 grains per gallon, and that this residue consisted largely of magnesium and calcium compounds it was not difficult to explain the presence of so much chlorine.

Nitrates and Nitrites: In some instances where the water is suspected as having been the cause of typhoid fever, tests are made for nitrates and nitrites.

Drinking Water in its Relation to Disease.

While it is not possible in a paper of this nature to fully discuss the relation between drinking water and disease, yet it may be stated that it is a well established fact that impure water is a fruitful cause of disease, and that in the majority of cases the disease is caused by the organic matter present. It is believed that matter which is in suspension is the most harmful, and especially when derived from recent sewage and fecal matter. Dr. A. H. Hassall, in his treatise on drinking water, states that the following diseases and disorders have all been produced by impure water, namely: dysentery, dyspepsia, diarrhœa, cholera, typhoid fever, scarlet fever, malarious fever and ague. Typhoid fever germs cannot exist for any length of time in pure cold spring water, because there is too little for them to feed upon, but polluted waters furnish the necessary conditions for their growth and multiplication, in the products of decomposing organic matter.

The Michigan State Board of Health, after a careful study of the subject, has established a very close relation between the depth of water in wells and sickness from typhoid fever. The maximum of sickness and minimum of water are coincident in the month of October. This is probably due to the fact that when the water is lowest its contaminations are most concentrated. The frequent outbreaks of typhoid fever which are directly and unmistakably traceable to drinking water contaminated with infected matter from typhoid fever patients point to this as the chief source of danger.

The following, taken from a document issued by the Michigan State Board of Health, should receive the thoughtful attention of every one:

"The most scrupulous care should be taken to keep the present sources of drinking water pure, and to procure future supplies only from clean sources. The general water supply of cities and villages is a matter of greatest concern; it should be procured from places where there can be no probability of immidiate or remote contamination. The well known outbreak of typhoid fever at Plymouth, Pa., where over a thousand cases and one hundred and fourteen (114) deaths occurred, is apparently an illustration of how great a calamity may follow the fouling of a general water supply by the discharges of a person sick with typhoid fever. When there is no general water supply, nor good sewers, much may be done to protect wells by the abolition of cess-pitts and privy vaults, by the use of dry earth in privies, and by the frequent removal therefrom of all their contents. * * * Privies often drain into wells, unsuspected by those who use the water. Should typhoid fever discharges pass into such a privy, an outbreak of typhoid fever among those using the water from a neighboring well would be likely to occur. If such a well were the source of the general water supply of a city, typhoid fever might soon be epidemic there. * * * There is good reason to suspect the water of a well whenever a vault is situated within a hundred feet of it, particularly if the soil be porous. In numerous instances fluids from excreta have leached into wells from much greater distances; and it has been proved that a well thirty rods from a cemetery received water which had filtered through the soil of the cemetery. Dangerously contaminated water may be, and often is found to be, clear and colorless, and to have no bad taste."

The noted instance at Lausanne, Switzerland, where the discharges from typhoid fever patients were thrown into a small stream, which disappeared by sinking into the earth and gravel and reappeared about a half a mile distant as a mountain spring, the clear water of which caused typhoid fever in one hundred and forty-four (144) persons, is instructive, and is worthy of note as illustrating how the disease may be spread. Filth and bad sani-

tary conditions of premises generally, increase the danger of spreading typhoid fever. Good water supplies, drainage and sewers, generally restrict typhoid fever, as well as other communicable diseases. One should not drink water which has a bad taste or odor, or which comes from a source that renders it likely to be impure.

The following table shows results of the analysis of a number of samples of water sent to the Station during the past year. All classes of water from very bad to exceedingly pure are represented.

A careful study of the table discloses the fact that the driven and artesian well waters are in most instances comparatively free from organic impurities, and that of the dug wells, those that are deepest furnish water of a higher degree of organic purity than the shallow wells.

CHEMICAL ANALYSES OF DRINKING WATERS.

Experiment Station Number.	Description of Water.	Grains per U. S. Gallon.			Parts per Million.		Remarks
		Total Solids.	Chlorine.	Hardness. Equivalence in Carbonate of Lime.	Free Ammonia.	Albuminoid Ammonia.	
10487	Spring	1.50	0 250	0.416	.0800	.1100	Organic contamination, suspicious.
10488	Pond	7.41	0.416	1 000	.4 00	5340	Very foul, exceedingly dangerous.
10500	City hydrant	5.91	0.416	2.330	3600	.1877	Organic contamination, very bad.
10502	City supply	3.33	0.330	0.580	.0449	.2155	Organic contamination, very suspicious.
10506	City supply	5.08	1.250	0 780	.2400	.1935	Contaminated to a dangerous extent.
10507	City hall hydrant, ci y supply	4 08	0.766	0.910	.0233	0435	Good safe water.
10512	Hydrant, city supply	3.67	0.275	0.750	1730	.0505	Fair water.
10513	Public hydrant, city supply	3.25	0.250	0.420	.0670	.0203	Good safe water.
10517	Hydrant, city supply	4.58	0.300	0.920	.0310	.0787	Fair safe water.
10518	Pump at residence	4 33	0.400	1 200	.0270	.0237	Good pure water.
10519	Pump at residence	5.58	1.160	1.210	0282	.0362	Good pure water.
10526	Well	5.83	0.330	2.225	.0682	.1240	Organic matter present, suspicious.
10531	Well No. 1, city supply	2.92	0.460	1 250	.0510	.0500	Pure water.
10532	Well No. 2, city supply	3 25	0 670	1.920	.0316	.0500	Pure water.
10533	Well No 3, city supply	3.17	0.250	1 080	.0500	.0487	Pure water.
10534	Well No. 4, city supply	1.17	0.208	0.670	.0440	.0312	Pure water.
10537	Pump	23.67	0.670	16.580	.0366	.7300	Exceedingly dangerous on account of organic contamination, very hard.
10542	Well	2.75	0.420	0.625	.0600	.3850	Highly contaminated, dangerous
10548	Pump, suspected	6.66	1.330	0 920	.7730	.0610	Very suspicious.
10553	Driven well	1.33	0.250	0.420	.0082	.0175	Very pure water.

10554	Driven well 2,500 feet from building.	2.66	0.250	0.540	.0100	.0237	Very pure water.
10555	Well	21.33	3.000	10.830	0100	.0412	Good safe water, but hard.
10556	Well	14.50	1.960	9.330	.0082	.0737	Safe pure water, but hard.
10557	Spring water	14.25	2.170	4.170	.0849	4575	Dangerous water for drinking.
10568	Spring water	4.66	0.250	1.000	.0066	.1450	Slightly contaminated with organic matter, suspicious.
10581	Well water	5.08	1.000	0.830	.1060	.3162	Organic contamination to a dangerous extent.
10582	Artesian well, 765 feet deep	12.75	0 580	4.160	.0000	.0325	Very pure water.
10583	Driven well	5.00	0.166	1.500	.0033	.0075	Exceedingly pure water.
10597	City supply	2.16	0.160	0.330	.0130	.0325	Very pure water.
10598	City supply	9.58	0.790	2.160	.0073	.0175	Very pure water.
10601	City supply	4 83	0.250	1.750	.0049	.0899	Safe pure water.
10603	Camp supply	4.92	0.170	0 5 0	.0700	.3100	Contaminated to a dangerous extent.
10605	Public well about 50 feet deep, wooden wall.	4.33	0.350	1.170	.0961	.2162	Probably contaminated by vegetable matter, very suspicious.
10606	Public well about 50 feet deep, wooden wall.	4.00	0.330	0 920	.1000	.1700	Probably contaminated by vegetable matter, very suspicious.
10607	Reservoir on small stream	4.83	0.175	0.420	.0300	.2275	Probably contaminated by vegetable matter, very suspicious.
10608	Well	2.75	0 420	0 920	.0100	.1375	Contained green moss, very suspicious.
10610	Well	6.92	0 920	2 080	.01 0	.0325	Good pure water.
10611	Surface well, 20 feet deep	20.83	11 250	3.120	.0130	.2225	Organic matter present, very suspicious.
10612	Driven well, city supply	4.83	0.166	1.160	.0082	.0175	Very pure water.
10614	Well, 80 feet deep.	4.50	0.330	1.830	.0166	.0109	Very pure water.
10615	Artesian well.	9.58	0.500	6.460	.0100	.0575	Good pure water, but rather hard.
10618	Well, suspected	14.83	3.000	6 830	.0233	.2050	Wholly unfit for drinking.
10622	Well, suspected	10.66	1.700	2.660	.2130	.2325	Dangerous for drinking.
10623	Cistern water	9.42	0.170	2.380	.0082	.0675	Good pure water.
10624	Surface well	8.50	0 960	3 480	.0660	.0670	Good safe water.
10625	Well	29.75	2.830	23.330	.0900	.1062	Some organic contamination, suspicious; very hard.
10627	Well near cotton mills	28.58	3.000	21.660	.0000	.0562	Pure water, but very hard.
10632	Well	11.33	1.080	3.750	0000	.0450	Good pure water.
10633	Well	8.75	1.660	3.920	.0060	.0412	Good pure water.
10639	Artesian well	9.80	0.625	4.170	.0066	.0350	Good water.
10640	Well	2.00	0.250	0.500	.0383	.0300	Very pure water
10641	Well	2.33	0.250	1.000	.0300	.0650	Good pure water.
10642	Artesian well	3.42	0.290	1.170	.0066	.0212	Pure water.
10643	Well	6.70	0.200	1.700	.0233	.0175	Pure water.
10674	Artesian well	12.50	0.330	8.580	.2130	.0175	Good water, but hard.

CHEMICAL ANALYSES OF DRINKING WATERS—CONTINUED.

Experiment Station Number.	Description of Water.	Grains per U. S. Gallon.			Parts per Million.		Remarks.
		Total Solids.	Chlorine.	Hardness. Equivalence in Carbonate of Lime.	Free Ammonia.	Albuminoid Ammonia.	
10675	Artesian well, 52 feet deep	13.92	0 290	10.580	.1000	.0550	Safe pure water, but hard.
10676	Driven pump	2.83	0.330	1.170	.0000	.0850	Safe pure water.
10677	Driven well, 45 feet deep	2.25	0.330	0.660	.0282	.0300	Very pure water.
10678	Artesian well, 115 feet deep	10.00	0.375	6.830	.0530	.0075	Very pure water.
10679	Well	28.00	2.870	18.080	.0033	.0425	Pure water, though very hard.
10680	Well	13.83	0.500	9.500	.0066	.0875	Safe pure water, though hard.
10681	Well near cotton mills	3.66	0.330	1.000	.0166	.0550	Pure water.
10682	Cistern	5.83	0.170	3.830	.0000	.0537	A pure water.
10683	Well, suspected	36.92	9.330	11.920	.0000	.0862	Nitrogen present as nitrates, suspicious, hard.
10685	Well, from yard convict quarters	15.45	4.080	4.580	.2600	.0650	Contaminated with organic matter, suspicious.
10687	Driven well	7.92	0.790	2.660	.0000	.0000	Exceedingly pure water.
10688	Spring	16.00	3.250	3.660	.0833	.0450	Fairly pure water.
10690	Spring	2.50	0.170	1.000	.0800	.0275	Pure safe water.
10691	Spring	2.08	0.170	0.920	.0233	.0275	Very pure water.
10692	Well, 10 feet from dwelling	9.00	2.420	2.580	.0460	.0925	Slight contamination.
10693	Well	13.50	0.660	9.920	.0460	.0325	Pure safe water.
10697	Pump near house	3.50	0.210	0.830	.0000	.0150	Very pure water.
10699	Surface spring	2.92	0.170	2.500	.0500	.0875	Slight organic contamination.
10700	Surface well	13.66	2.750	3.000	.0233	.0250	Very pure water.
10702	Artesian well	5.00	0.375	2.750	.0566	.0050	Very pure water.
10703	Artesian well	6.42	0.330	2.080	.0366	.0050	Very pure water.

10705	Well, near kitchen	7.33	1.670	2.250	.0730	.0612	Nitrogen present as nitrates, may become dangerous at any time.
10706	Well, 30 feet deep	1.50	0.250	0.830	.0130	.0275	Very pure water.
10707	Well, 43½ feet deep	24.75	0.250	13.920	.0130	.1125	Quite hard, suspicious on account of odor.
10712	Surface well, suspected	7.00	0.830	3.000	.0300	.0400	Nitrogen present as nitrates, may become dangerous at any time.
10713	Surface well, suspected	8.08	0.830	3.330	.0100	.0350	Nitrogen present as nitrates, may become dangerous at any time.
10715	Pump, private house in city	1.08	0.170	1.170	.0033	.0100	Very pure water.
10716	Well, private house in city	3.42	0.290	1.080	.0249	.0350	Good, pure water.
10718	Surface well	2.67	0.120	0.920	.0149	.1375	Disagreeable odor, very suspicious.
10721	Well, public institution	5.83	0.330	2 920	.0066	.1300	Some organic contamination, suspicious.
10727	Driven well, 26 feet deep	137.70	56.420	34.580	.0216	.1100	A very decided mineral water.
10729	Public well in a city	11.50	1.330	3 330	.0660	.0600	Indications of decomposing animal matter, foul odor.
10730	Surface well	3 66	0.330	1.000	.0166	.0550	Pure water.

Notes on the Table.

No. 10554—Sample from driven well two and one-half miles from town; water-shed uncontaminated.

No. 10582—Artesian well, located in a valley; supply for a town.

No. 10583—Sample taken from a flowing "tube well" in decomposed granite; well is 49 feet deep, with a water-shed free from all contamination.

No. 10615 is from a well 62 feet deep with 60 feet of three inch iron pipe passing through eighteen feet of sand, a crust of hard rock, then soft rock for forty feet, then into hard rock three feet, when a pocket or hollow was found, the drill dropping twelve inches and giving an abundant supply of water. Water in pipe stands 6½ feet from surface.

No. 10639—Artesian well; supply for a town.

No. 10642—Sample was taken from a well two and one-half miles from a town; well flows about ten gallons per minute—temperature 60°. Water is delivered about four feet above ground.

No. 10674—From an artesian well 74 feet deep; water overflows continually.

No. 10677—From driven well; overflows at the rate of about two gallons per minute; depth 45 feet; located on hill near branch.

No. 10678—From driven well, 115 feet deep; flows fifty gallons per minute; has been flowing for about two years and is main supply for a town.

No. 10687—From artesian well 42 feet deep; flows two feet above surface of ground; 900 feet from nearest building.

No. 10702—From artesian well flowing 2½ gallons per minute. Near a city; depth 30 feet.

No. 10703—From an artesian well flowing two gallons per minute. Near a city; depth 30 feet.

No. 10706—Is from a dug well 30 feet deep. It is lined with 12 inch vitrified tile and all joints except two at bottom are cemented. There is a stone reservoir 6 feet deep at base of tile.

No. 10730—From a dug well about 20 feet deep, which is curbed with terra cotta tubing. A galvanized iron pump is used.

It must be remembered that the remarks in regard to the purity or impurity of the samples of water mentioned in the table, refer to the chemical examination only, and do not necessarily mean that a biological examination would have justified the chemical interpretation in every instance.

In many cases the proper information in regard to kind and depth of well, sanitary conditions, and nature of the soil and underlying rock, has been wanting, and on this account the proper record could not always be made.

The following is a copy of the directions which the Station sends to those who wish to have drinking water analyzed:

DIRECTIONS FOR TAKING SAMPLES OF DRINKING WATER.

TO BE FORWARDED (EXPRESS PREPAID) TO THE N. C AGRICULTUAL EXPERIMENT STATION AT RALEIGH, FOR ANALYSIS.

Parties desiring a chemical examination of the waters of public or private wells, must first write to Dr. R. H. Lewis, Secretary State Board of Health, Raleigh, N. C., for permission to have such analysis made, and for one of these blanks, which must be approved by him. They must also state reasons for suspecting the water to be unhealthy. They should then obtain a sample according to the following directions: Secure one or more new demijohns or glass bottles, which should hold at least one gallon of each sample. Stone jugs must not be used, and when this requirement is not observed, no analysis will be made. Cleanse the bottle or demijohn thoroughly with hot water, then rinse several times with the water to be examined; fill, cork tightly with NEW CORKS thoroughly rinsed, and tie securely down; wax, putty, plaster or similar material should not be used for the purpose of sealing the bottle or demijohn.

In the examination of public water supplies, the sample should be drawn from a hydrant in direct connection with the main, and not from a cistern, storage tank or dead end of a pipe. In the case of pump wells, a few gallons of water should be pumped out before taking the sample, in order to remove that which has been standing in the pipe.

It is important that with each sample a record be made of those surroundings and conditions which might influence the character of the water, particularly in reference to sources of pollution, such as proximity to cess-pools, sewers or manufacturing establishments. Where it is possible, some information should be given concerning the rock formation of the locality, that is, whether it is linestone, granite, sandstone, etc.

Mark each sample with a designating number, and if the same sample is put into more than one bottle, be sure to put the same mark on all bottles which are alike. Pack in saw dust, or other packing, and *prepay express charges to Raleigh*. The analysis will be made free of charge, but neither the Experiment Station nor the State Board of Health has funds with which to pay express charges. Demijohns are returned without expense to sender when this is requested.

Having sent the samples directed to THE EXPERIMENT STATION, with your own name marked upon the package to designate the sender, fill out and send by mail the opposite blank. Samples sent during the winter run great risk of freezing and bursting the bottles.

The analysis will be made at a time when it does not conflict with the regular work of the Experiment Station. There will oftentimes be delays for this reason. This is especially the case during the fertilizer season in the spring and fall.

In the case of wells the following additional information should be given: Depth of well; depth of water in well; how lined, and whether it is an artesian, driven or dug well.